

CLAIMS

1. Pump apparatus for pumping a sample to an analyser
5 for analysis, comprising;
a first pump arranged to pump the sample into a buffer
region at a first flow rate, and
a second pump arranged subsequently to pump a second
fluid into said buffer region at a second flow rate to cause
10 at least a portion of the sample to be displaced from the
buffer region to the analyser, said second pump being
operable so that the second flow rate is more accurately
controllable than the first flow rate.
- 15 2. Apparatus according to claim 1, further comprising a
mixer disposed downstream of the buffer region and upstream
of the analyser on a buffer outlet conduit, said mixer being
arranged to mix the sample with a diluent to dilute the
sample before analysis.
- 20 3. Apparatus according to claim 1 or 2, further comprising
a third pump arranged to pump the diluted sample to the
analyser at a third flow rate.
- 25 4. Apparatus according to claim 3, wherein the diluent is
pumped into the mixer at a fourth flow rate, said fourth
flow rate being substantially the difference between the
third and second flow rates.
- 30 5. Apparatus according to claim 4, wherein the third pump
is arranged to pump the diluent into the mixer.

6. Apparatus according to any preceding claim, wherein the buffer region is arranged to have a first and second port.

7. Apparatus according to claim 6, wherein the first pump
5 is arranged to dispose the sample into the buffer region via the first port and the second pump is arranged to disposed the second fluid into the buffer region via the second port.

8. Apparatus according to claim 6 or 7, further comprising
10 a flow switching means moveable between a first and second position, the flow switching means being so arranged that;

(a) when the switching means is in the first position, the buffer region is in fluid communication with the first pump,
15 and

(b) when the switching means is in the second position, the first buffer region port is in fluid communication with the mixer, and a second buffer region port is in fluid communication with the second pump.
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9. Apparatus according to claim 8, further comprises a waste conduit so arranged that,

when the switching means is in the first position, the buffer region is also in fluid communication with the waste
25 conduit.

10. Apparatus according to claim 8, wherein the switching means is arranged so that,

when the switching means is in the second position, the
30 waste conduit is in fluid communication with the first pump, the first pump being arranged to pump a flush agent.

11. Apparatus according to claim 8, 9 or 10, further comprising,

when the switching means is in the first position, the second pump is in fluid communication with the outlet conduit disposed between the mixer and buffer region, so that the second fluid can be pumped into the outlet conduit for displacement of the sample fluid or second fluid therein.

12. Apparatus according to claim 2 or 11, wherein the mixing region comprises two or more input tubes, a mixing portion and an exit tube,

a first input tube being arranged for communicating the sample fluid to the mixing portion from the buffer region, and

a second input tube being arranged for communicating the diluting agent to the mixing portion.

13. Apparatus according to claim 11 or 12, further comprising,

when the switching means is in the second position, the second pump is arranged to pump the sample fluid through the mixing region at the second flow rate, and

the third pump is arranged to pump the diluted sample fluid at a third flow rate

14. Apparatus according to any preceding claim, further comprising a controller for monitoring and/or adjusting at least one of the first, second or third pump means, and/or the switching means, during operation.

- 27 -

15. Apparatus according to claim 14, wherein the controller is a PC.

16. Apparatus according to claim 14 or 15, wherein the
5 controller is arranged to receive analysis data from the analyser.

17. Apparatus according to claims 13 and 16, wherein the
third rate is substantially equal to, or greater than, the
10 second rate, and
wherein the controller is arranged to adjust the first
and/or third rate in response to received analysis data.

18. Apparatus according to claim 17, wherein the controller
15 is arranged to adjust the flow rates in real time.

19. Apparatus according to claim 1, wherein the analyser is
a mass spectrometer, or an identity couple plasma mass
spectrometer.

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20. Apparatus according to claim 1, wherein the second pump
means comprise a piston pump.

21. An analyser for analysing a sample fluid, comprising a
25 pumping system according to any preceding claim.

22. An analyser according to claim 21, wherein the analyser
is a mass spectrometer, or an inductively couple plasma mass
spectrometer.

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23. A method for pumping a sample fluid for analysis to an
analysis instrument using a pumping apparatus comprising,

- 28 -

a buffer region for temporarily storing the sample fluid, the buffer region being arranged with at least two ports,

disposing the sample fluid in the buffer region using a
5 first pump means at a first flow rate through a first port,
and

the method comprising,

pumping a second fluid into the at least partially
filled buffer region at a second flow rate through a second
10 port, using a second pump means, thereby displacing the
sample fluid therein to the analyser.

Whereby the second pump means is more accurately
controllable than the first pump means

15 24. A method according to claim 23, wherein the apparatus
further comprises

a flow switching means moveable between a first and
second position, the flow switching means being so arranged
that;

20 (a) when the switching means is in the first position, the
buffer region is in fluid communication with the first pump,
and

(b) when the switching means is in the second position, the
first buffer region port is in fluid communication with the
25 mixer, and a second buffer region port is in fluid
communication with the second pump.

the method further comprising,

pumping the sample into the buffer when the flow
switching means is in the first position using the first
30 pump,

switching the flow switching means to the second
position, and

pumping the second fluid into the buffer region using the second pump for displacement of the sample therein.

25. A method according to claim 24, the apparatus further
5 comprising a waste conduit so arranged that, when the switching means is in the first position, a buffer region port is in fluid communication waste conduit,
the method further comprising,
pumping excess fluid in the buffer region to the waste
10 conduit.

26. A method according to claim 25, further comprising,
when the switching means is in the second position, the waste conduit is in fluid communication with the first pump,
15 and the first pump pumps a flush agent.

27. A method according to any of claims 24 to 26, further comprising,
when the switching means is in the first position, the
20 second pump is in fluid communication with the outlet conduit, and
the second pump pumps the second fluid into the outlet conduit for displacement of the sample fluid or second fluid therein.

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28. A method according to any of claims 24 to 27, the apparatus further comprising,
a mixing region for mixing the sample fluid with a diluting agent, and
30 a third pump means pumps diluted sample fluid from the mixing region to the analyser,

- 30 -

wherein, the mixing region is disposed between the outlet conduit and the analyser;

the method further comprising,

when the switching means is in the second position,

5 the second pump means pumps sample fluid into the buffer region at a second flow rate,

the third pump means pumps the diluted sample fluid at a third flow rate, and

10 the third pump means pumps the diluting agent at a fourth flow rate substantially equal to the difference of the third and second flow rate.

29. A method according to any of claims 24 to 28, wherein the apparatus further comprises a controller which monitors and/or adjusts at least one of the first, second or third pump means, and/or the switching means.

30. A method according to claim 29, wherein the controller receives analysis data from the analyser.

31. A method according to claim 28 and 30, wherein the third rate is substantially equal to, or greater than, the second rate, and

25 wherein the controller adjusts the first and/or third rate in response to the received analysis data.

32. A method according to claim 31, wherein the controller adjusts the flow rates in real time.

30 33. A method for diluting a sample fluid, using apparatus according to any of claims 1 to 22, and a method according to any of claims 23 to 32.

- 31 -

34. A computer program which, when run on a computer, carries out the method according to any of claims 23 to 33.

5 35. An electronic carrier means on which is stored the computer program according to claim 33.

36. A method of preventing contamination of a first pump means with a sample, the method comprising;

10 disposing the sample in an intermediary region using a second pump,

displacing the sample from the intermediary region by pumping a second fluid into said intermediary region using the first pump means.

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37. A diluting system for diluting a sample fluid for analysis, comprising;

a buffer region for storing the sample fluid arranged with an input and output,

20 a first pump means for pumping the sample fluid into a sample fluid buffer region through the input,

a second pump means for pumping a second fluid into the buffer region through the output,

25 an outlet conduit arranged for flow of the sample fluid and/or fluid to the analyser

a mixing region for mixing the sample fluid with a diluting agent,

a third pump means for pumping diluted sample fluid from the mixing region to the analyser, and

30 a flow switching means moveable between a first and second position, so arranged that,

- 32 -

when the switching means is in the first position, the buffer region input is in communication with the first pump and the sample fluid can be pumped into the buffer region, and

5 when the switching means is in the second position, the buffer region input is in communication with the outlet conduit, and the buffer region output is in communication with the second pump so that the second fluid can be pumped into the buffer region for displacement of the sample fluid
10 therein, and wherein, the mixing region is disposed between the outlet conduit and the analyser.

38. A method for diluting a sample fluid for analysis using a dilution system comprising,

15 a buffer region for storing the sample fluid arranged with an input and output,
 an outlet conduit arranged for flow of the sample fluid and/or the second fluid to the analyser,

 a mixing region for mixing the sample fluid with a
20 diluting agent, and

 a third pump means arranged to pump diluted sample fluid from the mixing region to the analyser, the mixing region is disposed between the outlet conduit and the analyser, and

25 a flow switching means moveable between a first and second position, so arranged that, when the switching means is in the first position, the buffer region input is in communication with a first pump, and when the switching means is in the second position, the buffer region input is
30 in communication with the outlet conduit, and the buffer region output is in communication with a second pump;

 the method comprising,

- 33 -

pumping the sample fluid into the sample fluid buffer region through the input when the switching means is in the first position, using the first pump means,

switching the switching means to the second position,

5 pumping a fluid into the buffer region through the output, thereby displacing the sample fluid therein to the outlet conduit,

when the switching means is in the second position, the second pump means pumps the second fluid into the buffer

10 region at a first flow rate, such that the sample fluid proceeds through the mixing region at the first flow rate,

the third pump means pumps the diluted sample fluid at a third flow rate, and

the third pump means pumps the diluting agent at a
15 second flow rate substantially equal to the difference of the third and first flow rate.

39. A method of pumping a fluid sample through a dilutor using a first pump, for analysis of the diluted fluid sample
20 downstream of said dilutor, said first pump being isolated from said fluid sample, the method comprising:

disposing said fluid sample in an intermediary region using a second pump, said intermediary region having a first and second port through which fluid can flow,

25 displacing at least a portion of said fluid sample from the intermediary region through the first port by inserting a second fluid into the intermediary region through the second port using the first pump, the first port being in fluid communication with the diluter so that the at least a
30 portion of said fluid sample is displaced into the diluter from the intermediary region.

- 34 -

40. A method according to any of claims 23 to 39, further comprising;

disposing an internal standard into the sample, said internal standard comprising a known concentration of a predetermined substance, and

determining the factor by which the sample is diluted by comparing the detected concentration of the internal standard with the known concentration of the internal standard in the undiluted sample.

41. A method according to claim 40, wherein a second internal standard comprising a known concentration of a second predetermined substance is disposed in the sample and the diluent at the same second concentration levels.

42. A method according to claim 40 or 41, further comprising;

determining the dilution factor from the amount of the first internal standard detected by the analyser,

determining a correction factor by comparing the determined dilution factor with an expected dilution factor, and

using the correction factor to correct analyser data.

43. Apparatus according to claim 1, wherein the sample and/or the diluent contain an internal standard which comprises a predetermined amount of a known substance, and a dilution factor by which the sample is diluted is calculable by comparing the detected amount of said internal standard by the analyser with the amount of internal standard in the sample or diluent.